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# INDUCTION OF LATERAL BRANCHING IN NURSERY TREES

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## ABSTRACT

One year old nursery trees of *Malus domestica* Borkh. 'Boskoop', 'Elise' and 'Rubin' on M9 rootstock were headed in nursery or treated with foliar sprays of: Arbolin 36SL, Arbolin Extra and Promalin at 900 ppm or 1800 ppm a.i. The branching effect was correlated with an increase of rate of active ingredients (a.i.). BA+$GA_3$ based mixtures (Arbolin 36SL and Arbolin Extra) were better than BA+$GA_{4+7}$ mixture (Promalin). No tree injuries after using chemical branching agent were observed. The environmental condition plays a great role in induction of sylleptic shoots formation.

**Key words:** apple, branching, plant growth regulators.

## INTRODUCTION

High establishment new orchard costs necessitate early cropping to ensure an early return of investment. It is known that planting well-feathered nursery trees greatly contributes to early and high orchards crops [5, 15]. Although the beneficial effect of using initially branching trees diminishes with the tree age [12, 14] it provides bigger income in the first years after orchard planting and greatly shortens the investment period.

However, some nursery trees do not branch easily, at the proper height, required to form their crowns [3, 8]. The ability to form laterals differs greatly among various species and cultivars of fruit trees [21]. Physiologically, the main factor responsible for a tree branching potential is apical dominance. The phenomenon of apical dominance is though to be controlled by the interaction of endogenous growth hormones, especially auxins and gibberellins [1, 10]. Additionally, feathering may be influenced by other factors such as: plant density, cultural practices and climate [2, 17, 18, 19].

The objective of this study was to compare different ways of promoting lateral branching in young apple nursery trees.

## MATERIALS AND METHODS

The experiment was conducted in 2000 and 2002 year in the nursery of Garlica Murowana Research Station near Cracow, Poland. Year 2001 was excluded because of hail damage. Trees of three difficult-to-branch apple cultivars: 'Boskoop', 'Elise' and 'Rubin' were used for this study. All of them were budded on standard M9 rootstock. Tree spacing was 90 cm between rows and 30 cm in-row. In the nursery routine fertilizer, pest and weed control programs were applied.
The treatments were:

1. Control trees,
2. Arbolin 36SL (1.8 % BA + 1.8 % $GA_3$) – 900 mg active ingredients$\cdot l^{-1}$,
3. Arbolin Extra (3.6 % BA + 3.6 % $GA_3$) – 900 mg a.i.$\cdot l^{-1}$,
4. Promalin (1.8 % BA + 1.8 % $GA_{4+7}$) – 900 mg a.i.$\cdot l^{-1}$,
5. Arbolin 36SL – 1800 mg a.i.$\cdot l^{-1}$,
6. Arbolin Extra – 1800 mg a.i.$\cdot l^{-1}$,
7. Promalin – 1800 mg a.i.$\cdot l^{-1}$,
8. Heading.

Only the single application of plant growth regulators was performed. For each chemical treatment a wetting agent Adpros 850SL (5 ml$\cdot l^{-1}$) was added. The control trees were sprayed only with water solution of Adpros 850SL at 5 ml$\cdot l^{-1}$. The chemicals and heading were applied at the end of June, when the tree height was approximately 70-75 cm. Heading was conducted after the third well performed leaf. At the time of treatment, the trees had no branches.

The following measurements were made:

In October, before the harvest height and tree trunk diameter (10 cm beyond the graft) was measured. The percent of branched trees was evaluated. In experiment the trees with three or more laterals were considered to be feathered and their quantity was expressed as a percent of total number per treatment. In addition, the total number of laterals was counted, and the length of shoots (> 15 cm) was measured.

Experimental design was a complete randomized design with 20 trees per plot and four replications.

The experimental data were collected and subjected to analysis of variance using Statistica 6.0 programme. The means were separated by multiply Duncan's test at P = 0.95.

## RESULTS

All cultivars of apple tree studied were characterized by low natural ability to branch. However, their branching potential (responses to exogenous BA+GA compounds) differed from each other. The lowest branching potential was found by 'Rubin', then 'Elise' and finally 'Boskoop' which was the easiest to branch among investigated cultivars. These results are in agreement with previous reports [6, 8, 20, 21].

Untreated trees of all examinated cultivars demonstrated a distinct apical dominant growth habit with almost no lateral growth. Only a few natural-branched trees were found in experiment with cv. 'Boskoop' (tab. 2).

Many researchers pointed out that heading alone had little effect on branching with either cultivar [7, 9, 11, 13]. This study proved it. Although removal of the shoot tip by hand caused production of branches, but the number of laterals was insufficient (1.1-2.3 feather per tree) to form proper tree crown. Moreover, these feathers had too narrow angles.

**Table 1. Percent of feathered trees cv. 'Boskoop'**

| Treatment | % feathered trees | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 10.2 a* | 17.9 a | 14.1 a |
| Arbolin 36SL – 900 mg/l | 100.0 c | 89.5 c | 94.7 c |
| Arbolin Extra – 900 mg/l | 94.6 c | 97.4 c | 98.6 c |
| Promalin 3.6 – 900 mg/l | 100.0 c | 59.4 b | 77.0 b |
| Arbolin 36SL – 1800 mg/l | 97.3 c | 100.0 c | 98.6 c |
| Arbolin Extra – 1800 mg/l | 100.0 c | 100.0 c | 100.0 c |
| Promalin 3.6 – 1800 mg/l | 100.0 c | 88.9 c | 95.7 c |
| Heading | 30.0 b | 12.5 a | 21.2 a |
| | 78.1 b | 70.2 a | |

*Means marked with the same letter do not differ significantly at P = 0.95

**Table 2. Total number of feathers in maiden apple trees cv. 'Boskoop' as influenced by application of different branching methods**

| Treatment | No. of feathers/tree | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 0.4 a | 0.9 a | 0.7 a |
| Arbolin 36SL – 900 mg/l | 12.2 d | 8.4 c | 10.3 e |
| Arbolin Extra – 900 mg/l | 12.1 d | 8.5 c | 10.3 e |
| Promalin 3.6 – 900 mg/l | 9.6 c | 4.0 b | 6.8 c |
| Arbolin 36SL – 1800 mg/l | 12.8 d | 10.4 e | 11.6 f |
| Arbolin Extra – 1800 mg/l | 12.4 d | 10.0 e | 11.2 f |
| Promalin 3.6 – 1800 mg/l | 9.7 c | 5.9 c | 7.8 d |
| Heading | 2.1 b | 1.2 a | 1.6 b |
| | 8.81 b | 6.12 a | |

**Table 3. Total length of feathers in maiden apple trees cv. 'Boskoop' as influenced by application of different branching methods**

| Treatment | Total length of feathers, cm/tree | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 7.3 a | 6.9 a | 7.2 a |
| Arbolin 36SL – 900 mg/l | 141.8 d | 96.3 cd | 119.0 d |
| Arbolin Extra – 900 mg/l | 135.6 d | 97.2 cd | 116.0 d |
| Promalin 3.6 – 900 mg/l | 105.1 c | 50.2 b | 77.7 c |
| Arbolin 36SL – 1800 mg/l | 221.1 f | 117.1 d | 169.0 f |
| Arbolin Extra – 1800 mg/l | 189.0 e | 100.4 d | 145.0 e |
| Promalin 3.6 – 1800 mg/l | 104.0 c | 75.3 c | 89.6 c |
| Heading | 61.8 b | 33.2 b | 47.5 b |
| | 119.9 b | 71.5 a | |

**Table 4. Percent of feathered trees cv. 'Elise'**

| Treatment | % feathered trees | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 0.0 a | 5.1 a | 2.5 a |
| Arbolin 36SL – 900 mg/l | 90.2d | 56.1 c | 73.2 cd |
| Arbolin Extra – 900 mg/l | 100.0 d | 62.5 cd | 81.2 de |
| Promalin 3.6 – 900 mg/l | 100.0 d | 27.5 b | 63.7 c |
| Arbolin 36SL – 1800 mg/l | 100.0 d | 77.5 d | 88.7 e |
| Arbolin Extra – 1800 mg/l | 100.0 d | 77.5 d | 88.7 e |
| Promalin 3.6 – 1800 mg/l | 60.0 c | 65.0 cd | 62.5 c |
| Heading | 35.0 b | 35.0 b | 35.0 b |
| | 73.4 b | 50.9 a | |

**Table 5. Total number of feathers in maiden apple trees cv. 'Elise' as influenced by application of different branching methods**

| Treatment | No. of feathers/tree | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 0.0 a | 0.5 a | 0.2 a |
| Arbolin 36SL – 900 mg/l | 7.9 c | 3.8 c | 5.9 e |
| Arbolin Extra – 900 mg/l | 10.6 e | 4.1 c | 7.4 f |
| Promalin 3.6 – 900 mg/l | 8.1 c | 1.8 ab | 5.0 d |
| Arbolin 36SL – 1800 mg/l | 10.4 e | 7.1 e | 8.8 g |
| Arbolin Extra – 1800 mg/l | 9.1 d | 5.6 d | 7.4 f |
| Promalin 3.6 – 1800 mg/l | 2.5 b | 3.8 c | 3.2 c |
| Heading | 2.2 b | 2.3 b | 2.3 b |
| | 6.41 b | 3.65 a | |

**Table 6. Total length of feathers in maiden apple trees cv. 'Elise' as influenced by application of different branching methods**

| Treatment | Total length of feathers, cm/tree | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 0.0 a | 2.2 a | 1.1 a |
| Arbolin 36SL – 900 mg/l | 103.0 c | 34.7 b | 69.0 c |
| Arbolin Extra – 900 mg/l | 140.0 d | 47.0 b | 93.7 d |
| Promalin 3.6 – 900 mg/l | 87.7 c | 36.4 b | 62.0 bc |
| Arbolin 36SL – 1800 mg/l | 175.0 e | 41.1 b | 108.0 d |
| Arbolin Extra – 1800 mg/l | 97.4 c | 30.8 b | 64.1 bc |
| Promalin 3.6 – 1800 mg/l | 50.3 b | 45.5 b | 47.9 b |
| Heading | 55.8 b | 51.4 b | 53.6 bc |
| | 89.1 b | 36.2 a | |

**Table 7. Percent of feathered trees cv. 'Rubin'**

| Treatment | % feathered trees | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 0.0 a | 5.1 a | 2.5 a |
| Arbolin 36SL – 900 mg/l | 100.0 d | 55.0 c | 77.8 e |
| Arbolin Extra – 900 mg/l | 78.4 c | 43.2 bc | 60.8 d |
| Promalin 3.6 – 900 mg/l | 83.3 c | 13.9 a | 48.6 c |
| Arbolin 36SL – 1800 mg/l | 100.0 d | 88.6 d | 94.3 f |
| Arbolin Extra – 1800 mg/l | 100.0 d | 31.2 b | 65.6 d |
| Promalin 3.6 – 1800 mg/l | 33.3 b | 6.1 a | 19.7 b |
| Heading | 34.3 b | 3.8 a | 18.6 b |
| | 65.4 b | 30.7 a | |

**Table 8. Total number of feathers in maiden apple trees cv. 'Rubin' as influenced by application of different branching methods**

| Treatment | No. of feathers/tree | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 0.41 a | 0.18 a | 0.29 a |
| Arbolin 36SL – 900 mg/l | 7.67 d | 2.83 d | 5.25 de |
| Arbolin Extra – 900 mg/l | 6.75 cd | 2.40 cd | 4.58 d |
| Promalin 3.6 – 900 mg/l | 6.33 c | 0.94 ab | 3.63 c |
| Arbolin 36SL – 1800 mg/l | 6.00 c | 5.34 e | 5.67 e |
| Arbolin Extra – 1800 mg/l | 10.1 e | 1.81 bc | 5.93 e |
| Promalin 3.6 – 1800 mg/l | 2.18 b | 0.51 a | 1.34 b |
| Heading | 2.34 b | 1.06 ab | 1.70 b |
| | 5.14 b | 1.87 a | |

**Table 9. Total length of feathers in maiden apple trees cv. 'Rubin' as influenced by application of different branching methods**

| Treatment | Total length of feathers, cm/tree | | Mean |
|---|---|---|---|
| | 2000 | 2002 | |
| Control | 10.5 a | 7.2 a | 8.2 a |
| Arbolin 36SL – 900 mg/l | 76.4 d | 23.8 abc | 50.1 cd |
| Arbolin Extra – 900 mg/l | 45.5 bc | 33.7 bcd | 39.6 bc |
| Promalin 3.6 – 900 mg/l | 99.3 e | 19.3 ab | 59.6 d |
| Arbolin 36SL – 1800 mg/l | 103.0 e | 46.8 d | 74.9 e |
| Arbolin Extra – 1800 mg/l | 64.7 cd | 13.4 ab | 39.1 bc |
| Promalin 3.6 – 1800 mg/l | 42.6 b | 15.5 ab | 29.1 b |
| Heading | 77.0 d | 41.9 cd | 59.5 d |
| | 64.3 b | 25.3 a | |

The application of chemical branching agents is thought to be more beneficial in promoting a more desirable branching and canopy development [3, 5, 16]. In all examinated cultivars was found that the application of branching agents significantly reduced the apical dominance; both Arbolins and Promalin strongly affected branching of each cultivar tested as compared with control (tab. 1-9).

As far as the rate of chemical compounds is concerned, it is well established that nursery trees usually requires high doses of branching agents [4]. Data from experiment showed that branching effects ware positively correlated with an increase of compound rate. Irrespective of the type of branching agent high rates tended to stimulate shoot development more than lower rate did. For all of cultivars, the most efficient treatment and consequently the best quality of feathered trees was application of Arbolin 36SL at 1800 mg/l, which significantly outperformed all other treatments in total length of branches.

The data obtained in the experiment confirmed that not only the rate but also kind of active ingredients plays role. Within the same rate of active ingredients the better results were obtained with mixtures of BA and $GA_3$ (Arbolin) than mixture BA and $GA_{4+7}$ (Promalin). Surprisingly, even if the same quantity of mixture BA and $GA_3$ was used (Arbolin 36SL *versus* Arbolin Extra) the branching effect was different. Therefore it may be concluded that except the kind and the rate of active ingredient, the formulation of branching agent is very important.

No visual toxicity symptoms in chemical-treated trees were observed. However, the temporary terminal growth tree cessation was noticed, especially after using high rates of chemical compounds. This effect was evident when we compare the final tree height of treated and non-treated chemically trees. But he diameter of tree trunk was not affected by using chemicals (tab. 10, 11).

**Table 10. Vegetative growth characteristics of maiden apple trees – trunk diameter, mm**

| Treatment | 'Boskoop' | | 'Elise' | | 'Rubin' | |
|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2000 | 2002 | 2000 | 2002 |
| Control | 12.9 a | 11.6 a | 10.7 a | 10.3 a | 13.2 a | 12.9 a |
| Arbolin 36SL – 900 mg/l | 13.1 a | 12.5 a | 11.5 ab | 10.5 a | 12.2 a | 11.1 a |
| Arbolin Extra – 900 mg/l | 13.7 a | 12.4 a | 11.9 ab | 10.8 a | 12.0 a | 11.2 a |
| Promalin 3.6 – 900 mg/l | 12.4 a | 11.2 a | 10.7 a | 9.9 a | 13.8 a | 11.6 a |
| Arbolin 36SL – 1800 mg/l | 12.3 a | 11.1 a | 12.4 b | 11.2 a | 13.1 a | 12.8 a |
| Arbolin Extra – 1800 mg/l | 12.3 a | 11.0 a | 10.6 a | 9.9 a | 13.5 a | 11.3 a |
| Promalin 3.6 – 1800 mg/l | 13.0 a | 11.4 a | 10.7 a | 9.7 a | 12.8 a | 11.6 a |
| Heading | 12.2 a | 11.1 a | 10.6 a | 9.8 a | 13.0 a | 11.8 a |
| | 12.7 b | 11.5 a | 11.1 b | 10.3 a | 13.0 b | 11.8 a |

**Table 11. Vegetative growth characteristics of maiden apple trees – tree height, cm**

| Treatment | 'Boskoop' | | 'Elise' | | 'Rubin' | |
|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2000 | 2002 | 2000 | 2002 |
| Control | 153 b | 146 b | 146 b | 140 b | 141 b | 135 b |
| Arbolin 36SL – 900 mg/l | 133 a | 127 a | 136 a | 130 a | 131 a | 125 a |
| Arbolin Extra – 900 mg/l | 138 a | 128 a | 128 a | 127 a | 135 a | 129 a |
| Promalin 3.6 – 900 mg/l | 136 a | 130 a | 133 a | 122 a | 126 a | 128 a |
| Arbolin 36SL – 1800 mg/l | 141 a | 132 a | 135 a | 129 a | 134 a | 120 a |
| Arbolin Extra – 1800 mg/l | 133 a | 132 a | 140 ab | 136 ab | 137 ab | 131 a |
| Promalin 3.6 – 1800 mg/l | 132 a | 126 a | 142 ab | 133 a | 132 a | 122 a |
| Heading | 138 a | 135 a | 125 a | 120 a | 128 a | 126 a |
| | 138 b | 132 a | 136 b | 131 a | 133 b | 127 a |

The role of temperature, humidity, rainfalls and solar radiation has been widely recognized [17, 18, 19]. This study confirmed the big role of environmental factors on syllepsis in nursery apple trees. The experiment which is described here was carried out in completely different conditions. In year 2000 the weather was warm and during the treatment there were a lot of rainfalls what resulted high air humidity. Such climatic factors favor development of lateral shoots [17, 18]. On the contrary season 2002 was rather dry with some periods of droughts. Therefore in 2000 the quality of trees was better. Consequently, these trees shown better branching ability. Considering number of laterals and their total lengths it was in 2000 twice as in 2002.

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